Save Time and Money with Energy Modeling

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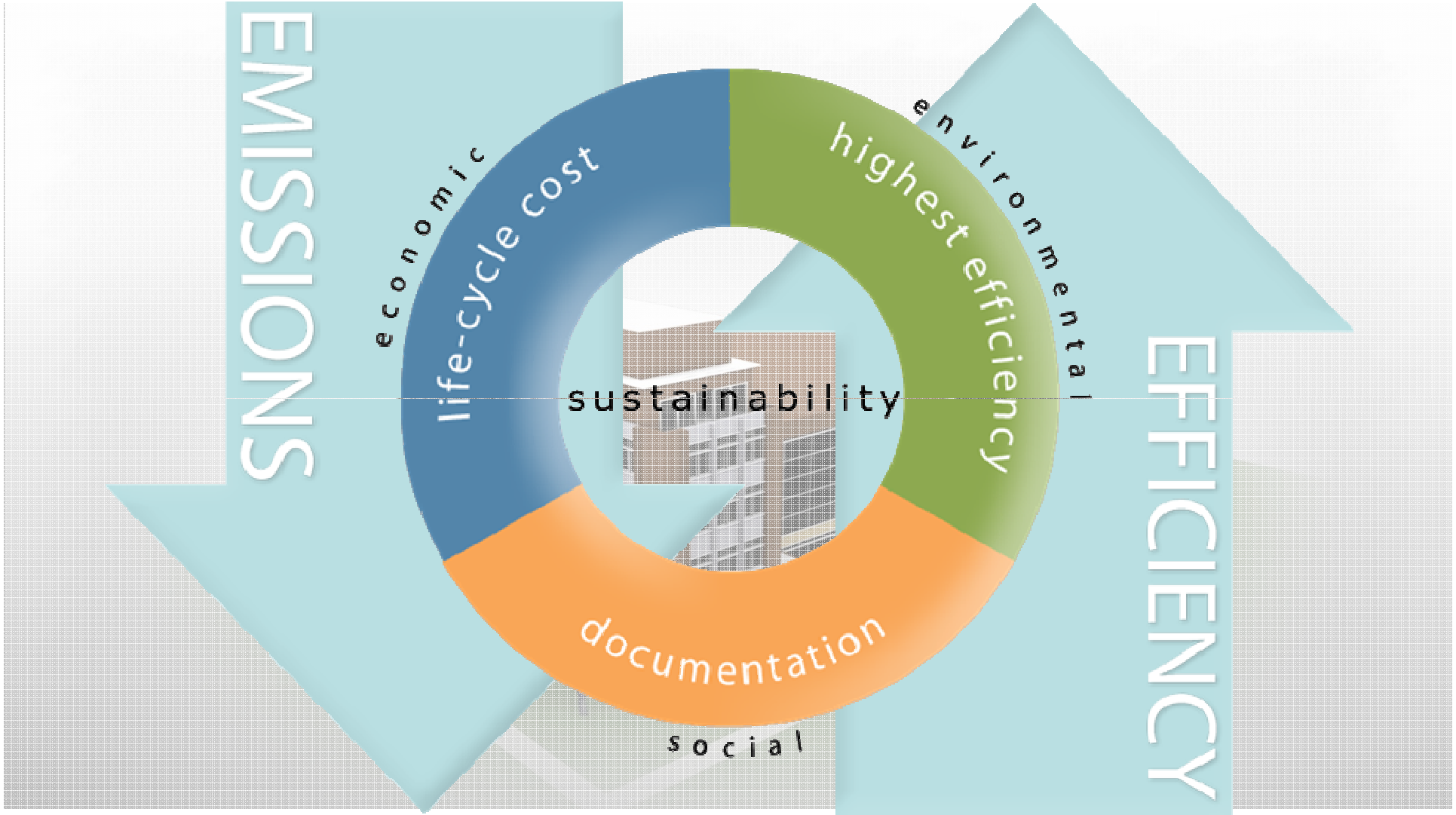
Market Trends & Dynamics

What happened in 2008?

- Buildings are longer term investments
- Sustainability – What does that mean?
  - **Engineers –** LEED, Green, ASHRAE
  - **Contractors –** Commissioning agent, VAV boxes in shrink wrap, multiple dumpsters
  - **Owners –** How much does it cost and what do I get for it?

- Giving our customers the ability to adapt to global changes and mitigate future risk.



Maximize Lifetime System Performance

Agenda

- What software is available
- What information is needed to complete a model
- 10 Simple Rules of Modeling
- How do standards tie into modeling
- What can be modeled today?
- Real World Examples
  - Chiller change out
  - Free cooling vs. Airside economizers
  - Bid Comparison
  - Live Example

Always, Always, Always….

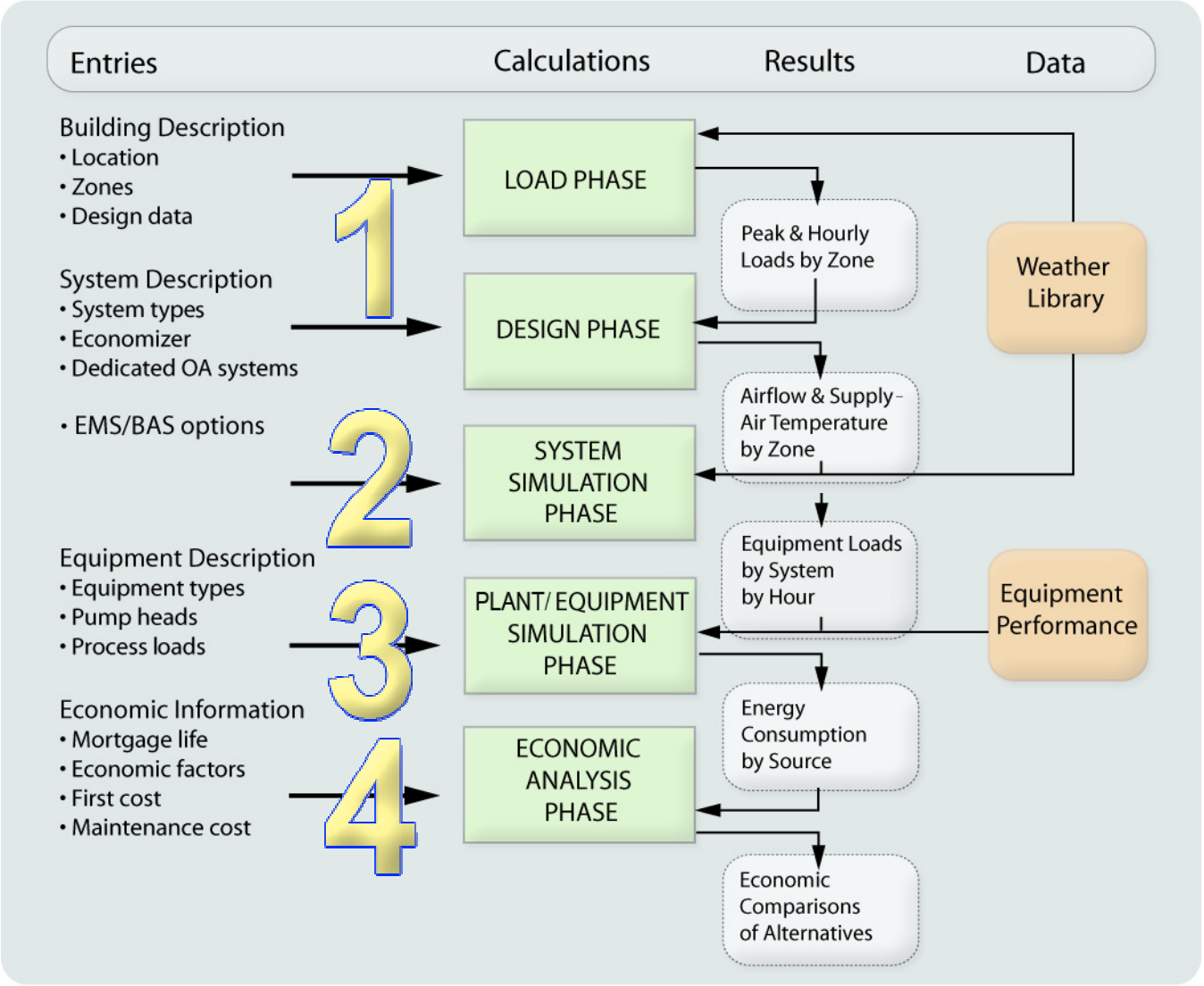
Remember the meter is on the building

What Software is Available

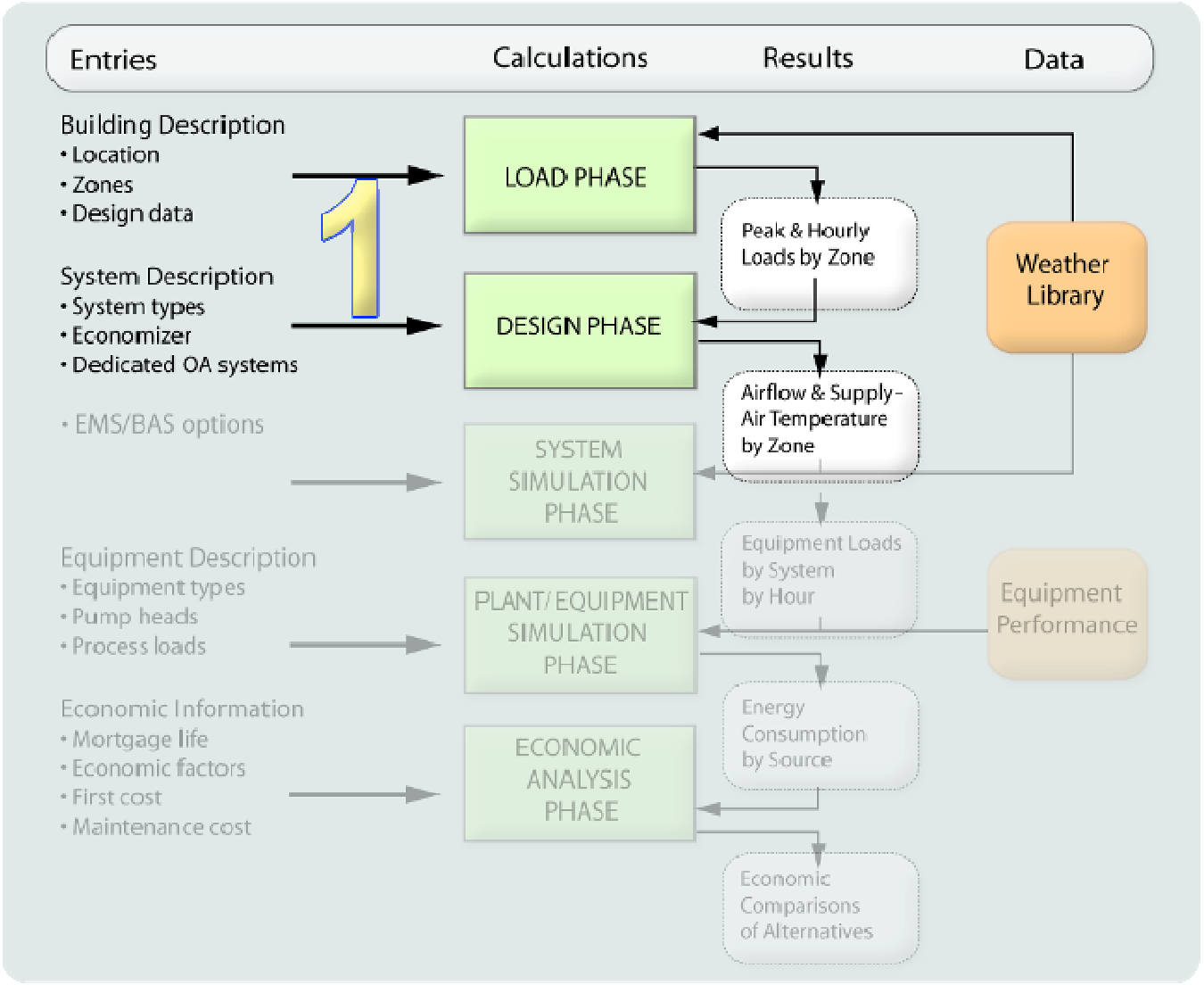
- DOE 2
- Visual DOE
- E-Quest
- Carrier HAP
- Trane TRACE 700
- Trane System Analyzer

- Do not use bin methods – misleading and not accurate

Four phases of Modeling



Four phases of Modeling

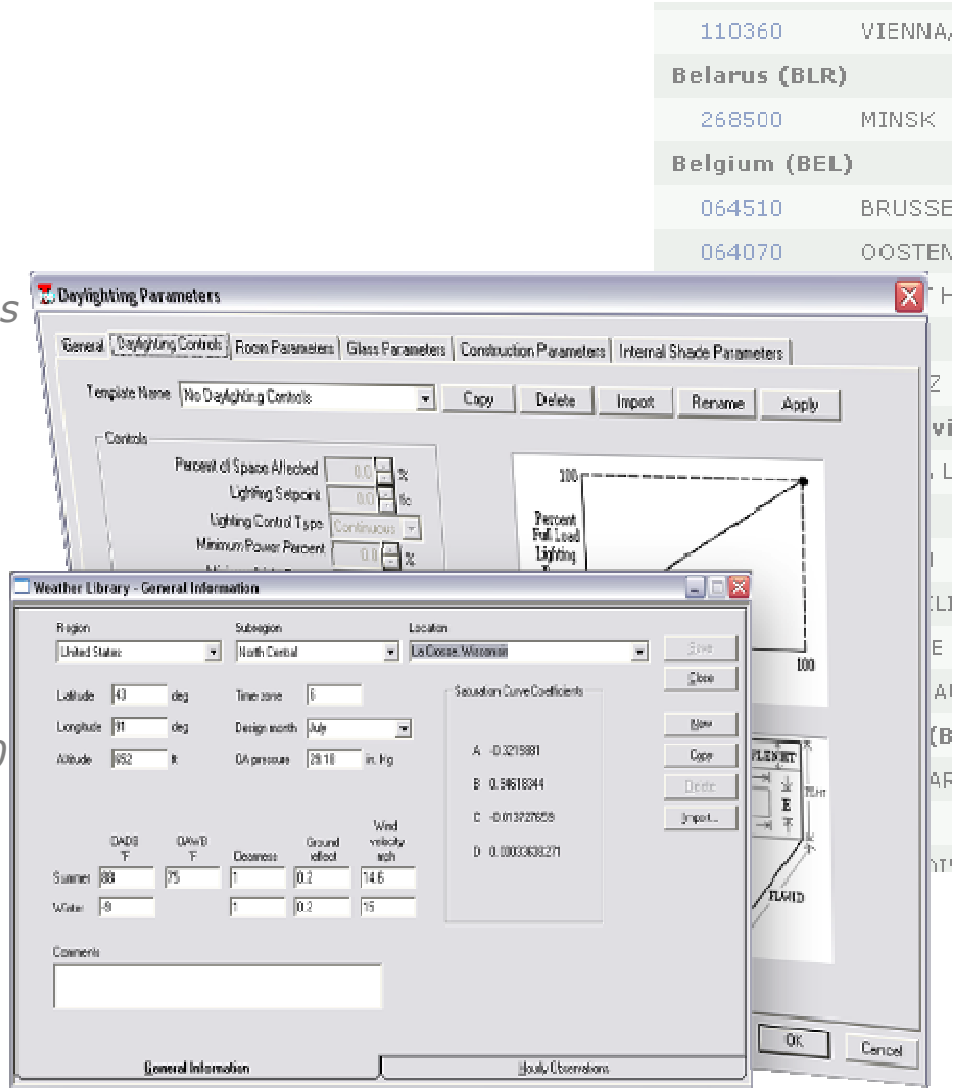


Modeling Functionality *Load Design*

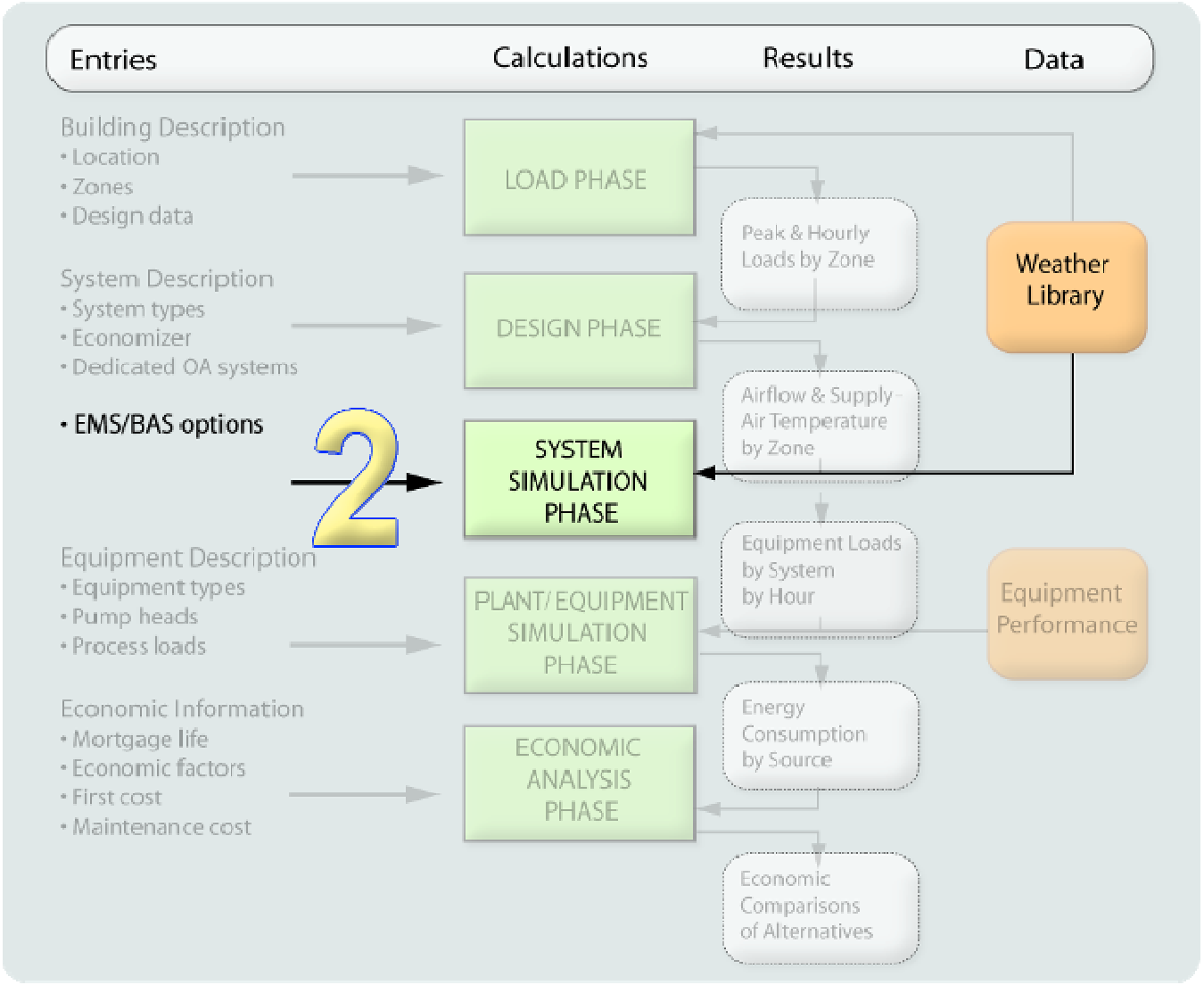
- Define building envelope
  - Weather profile
  - Construction types
    wall, roof, glass, etc
  - Loads
    people, lights, miscellaneous
  - Airflows
    cooling, heating, ventilation, infiltration, etc.

Modeling Functionality *Load Design*

- Select Features
  - Import weather files
    reduced and 8760
  - Templates
    apply common data to multiple rooms
  - Schedules
    apply common or custom schedules
  - ASHRAE Standard 62.1-2004
    Ventilation Rate Procedure
  - Daylighting controls
    define different control strategies
  - GBXML import capability
    import CAD drawings into TRACE 700



Phase 2: System Simulation



Modeling Functionality *System Simulation*

- Translates heat gains/losses to equipment loads
- More than 40 systems including:
  - Variable-volume

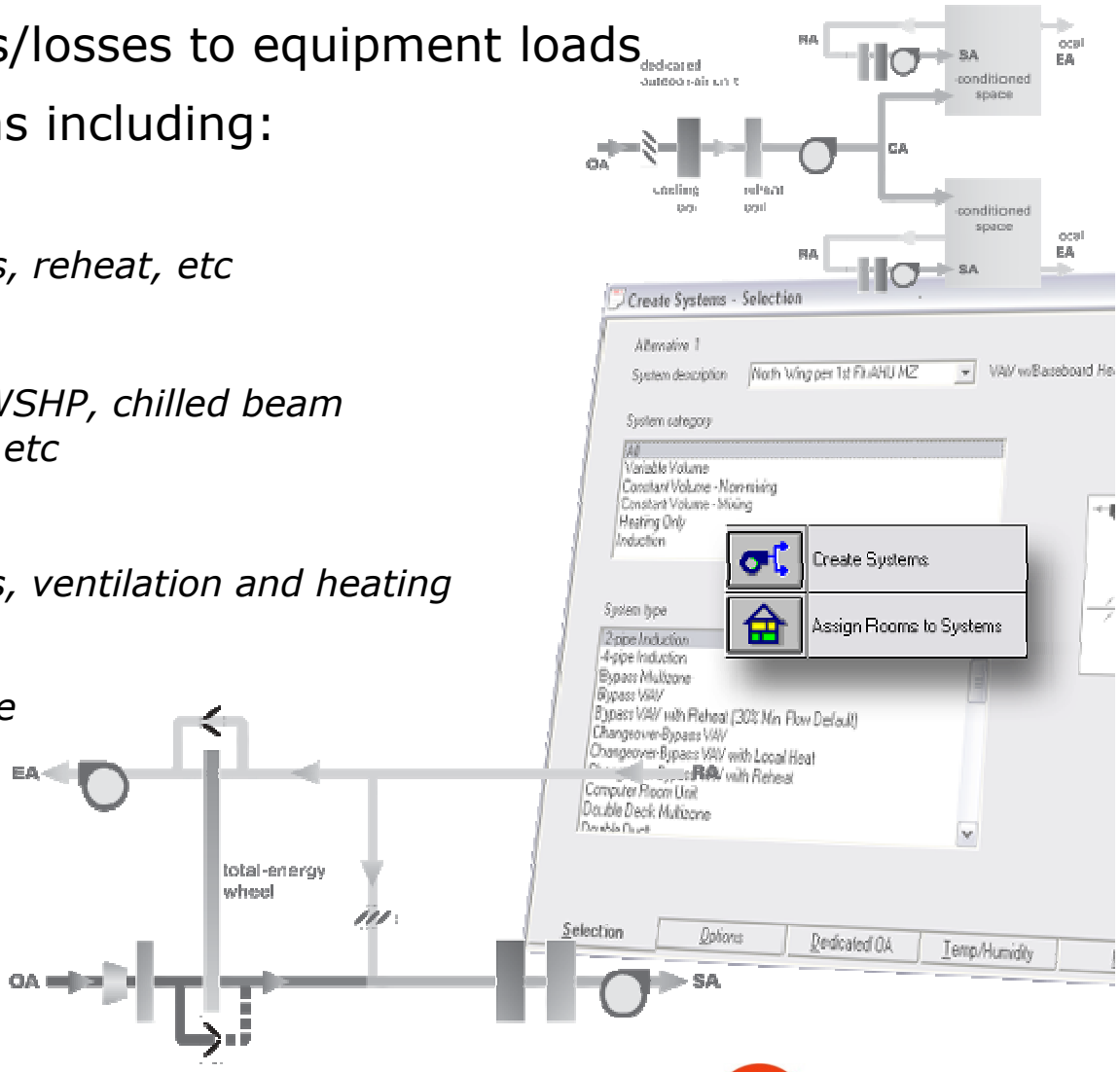
    bypass, parallel, series, reheat, etc
  - Constant-volume

    single zone, fan coil, WSHP, chilled beam variable-temperature, etc
  - Heating only

    Radiation, unit heaters, ventilation and heating
  - Induction

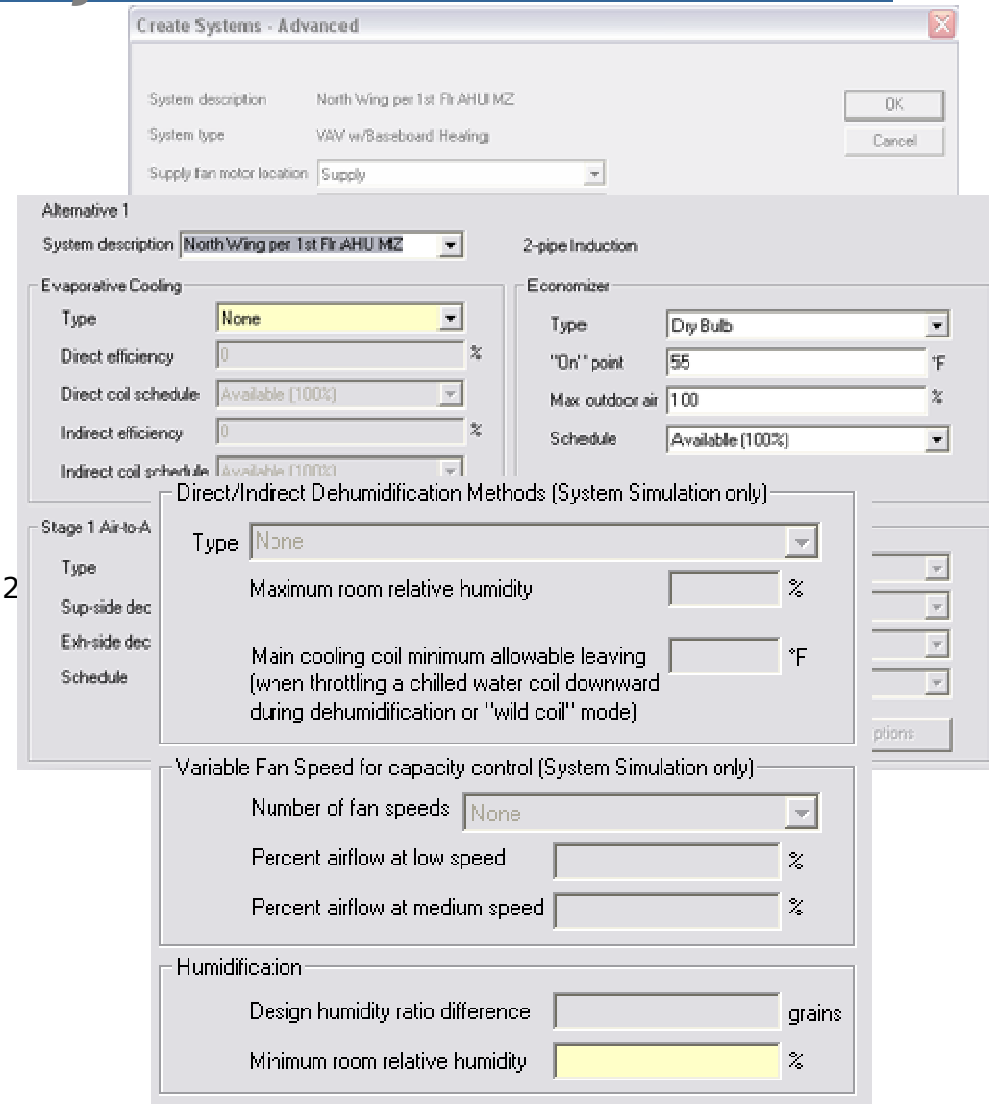
    Two-pipe and four-pipe
  - *Under Floor*

    Displacement Vent

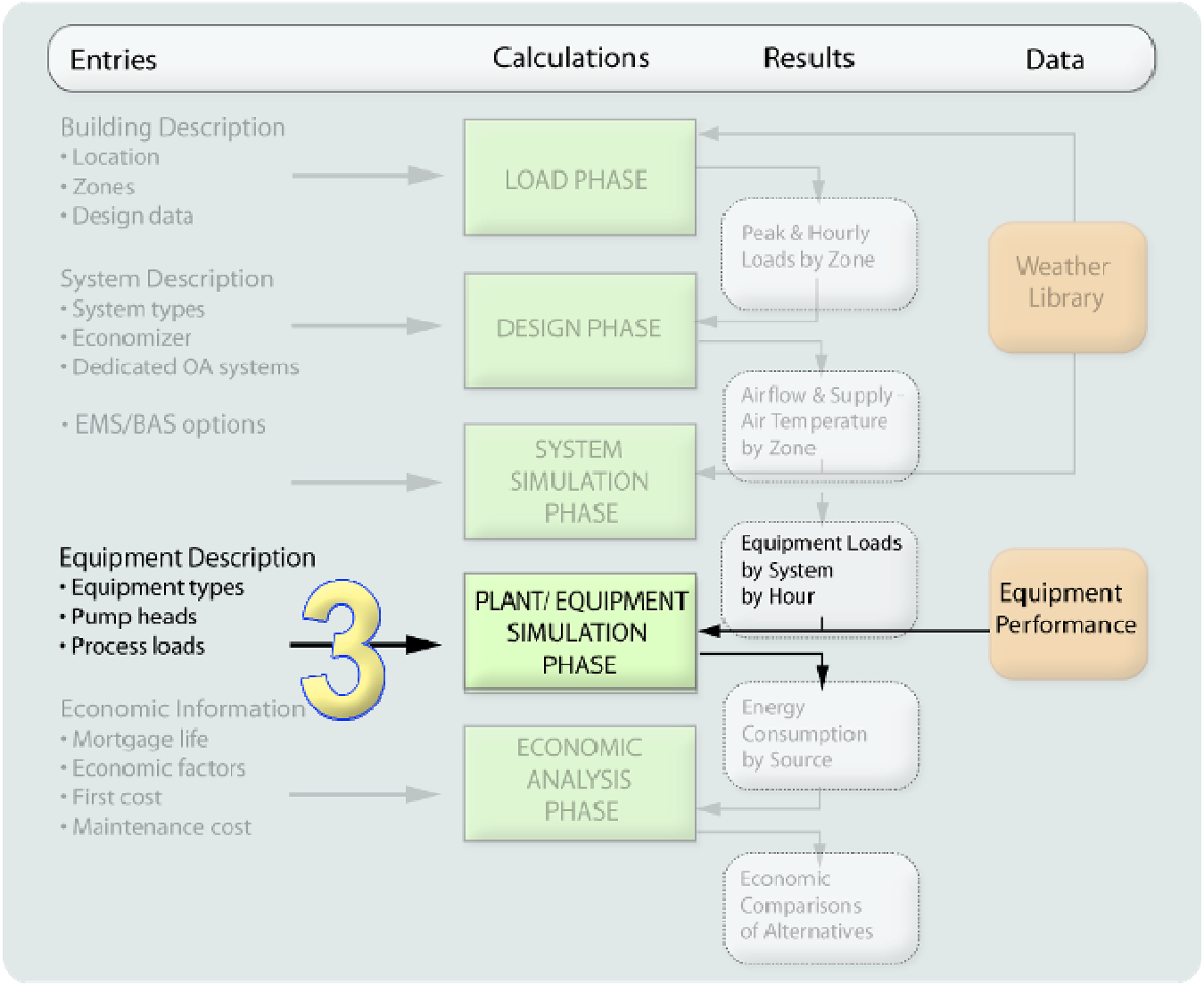


Modeling Functionality *System Simulation*

- Select Features
  - Evaporative cooling
  - Variable refrigerant
  - Dedicated-outdoor air
  - Airside economizers
  - Optimum start/stop
  - Fan pressure optimization
  - ASHRAE Standard 62.1/CO_2 based demand-controlled ventilation (DCV)
  - Energy recovery
  - Supply-air temperature Reset

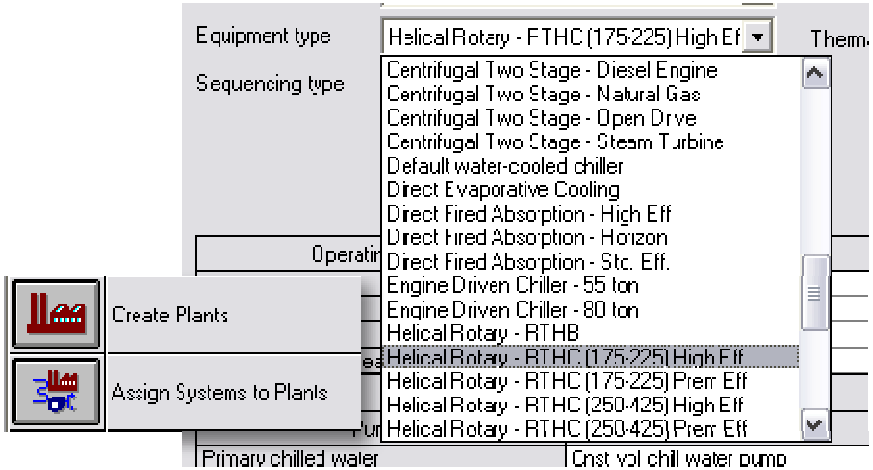


Phase 3: Plant/Equipment Simulation



Modeling Functionality *Plant/Equipment Simulation*

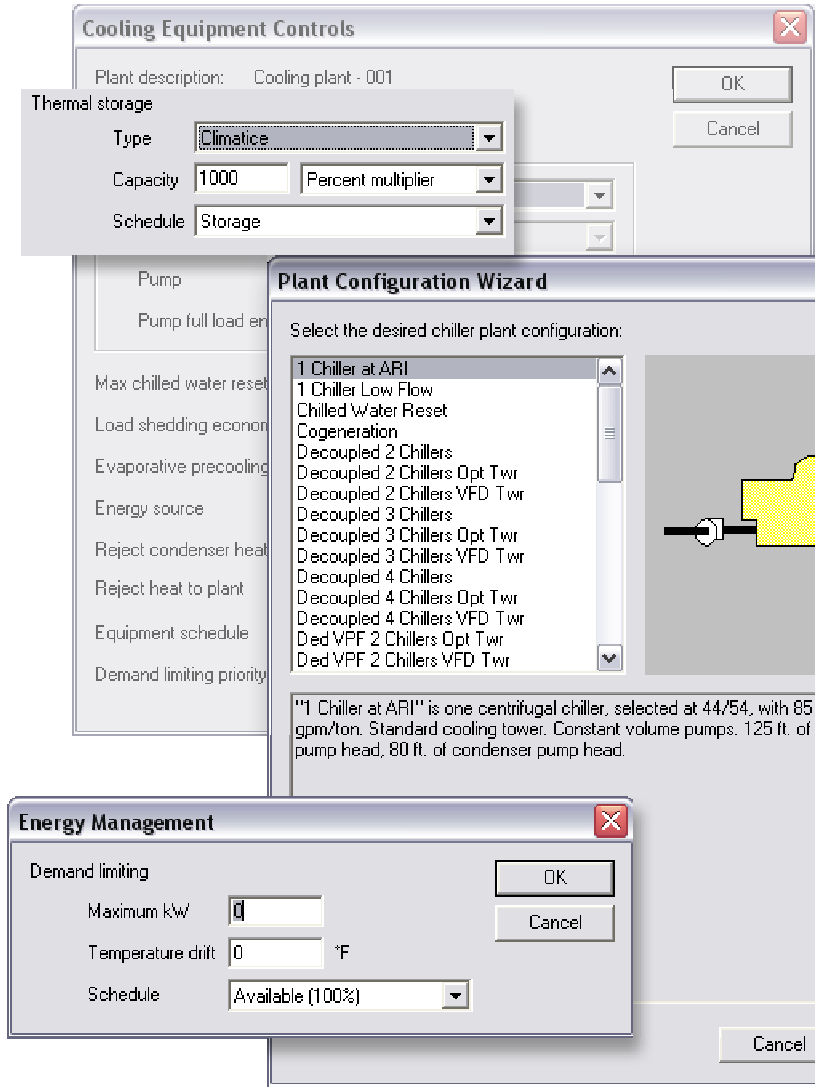
- Converts system loads to energy consumption
- Multiple equipment types:
  - Air/Water-cooled chillers
  - Air/Water-cooled unitary
  - Water/ground-source heat pumps
  - Boilers
  - Electric resistance heat
  - Gas-fired heat exchanger
- Equipment Library
  - Standard
  - ASHRAE Standard 90.1-2004
  - Custom



Modeling Functionality *Plant/Equipment Simulation*

Select Features

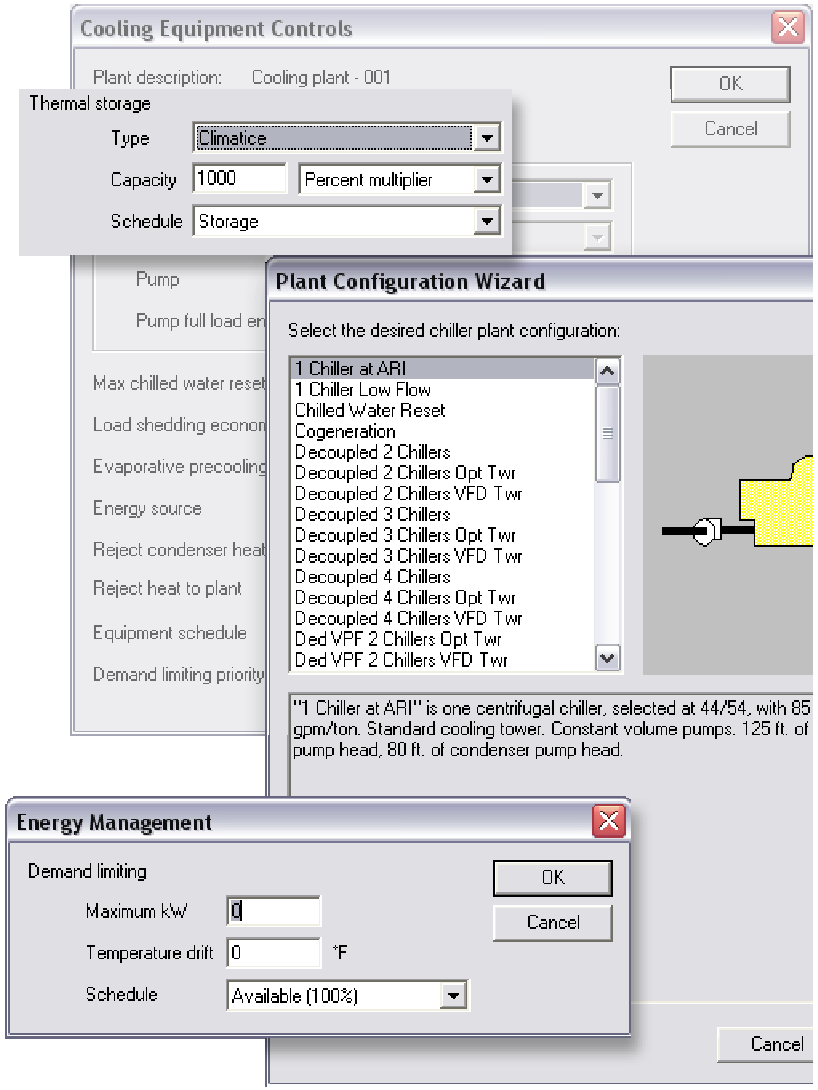
- Chiller Plant Wizard
  - Decoupled arrangement
  - Parallel/series
  - Variable-primary flow
  - Switchover control
- Cogeneration
- Thermal energy storage
- Direct-fired absorption
- Low-flow chilled water



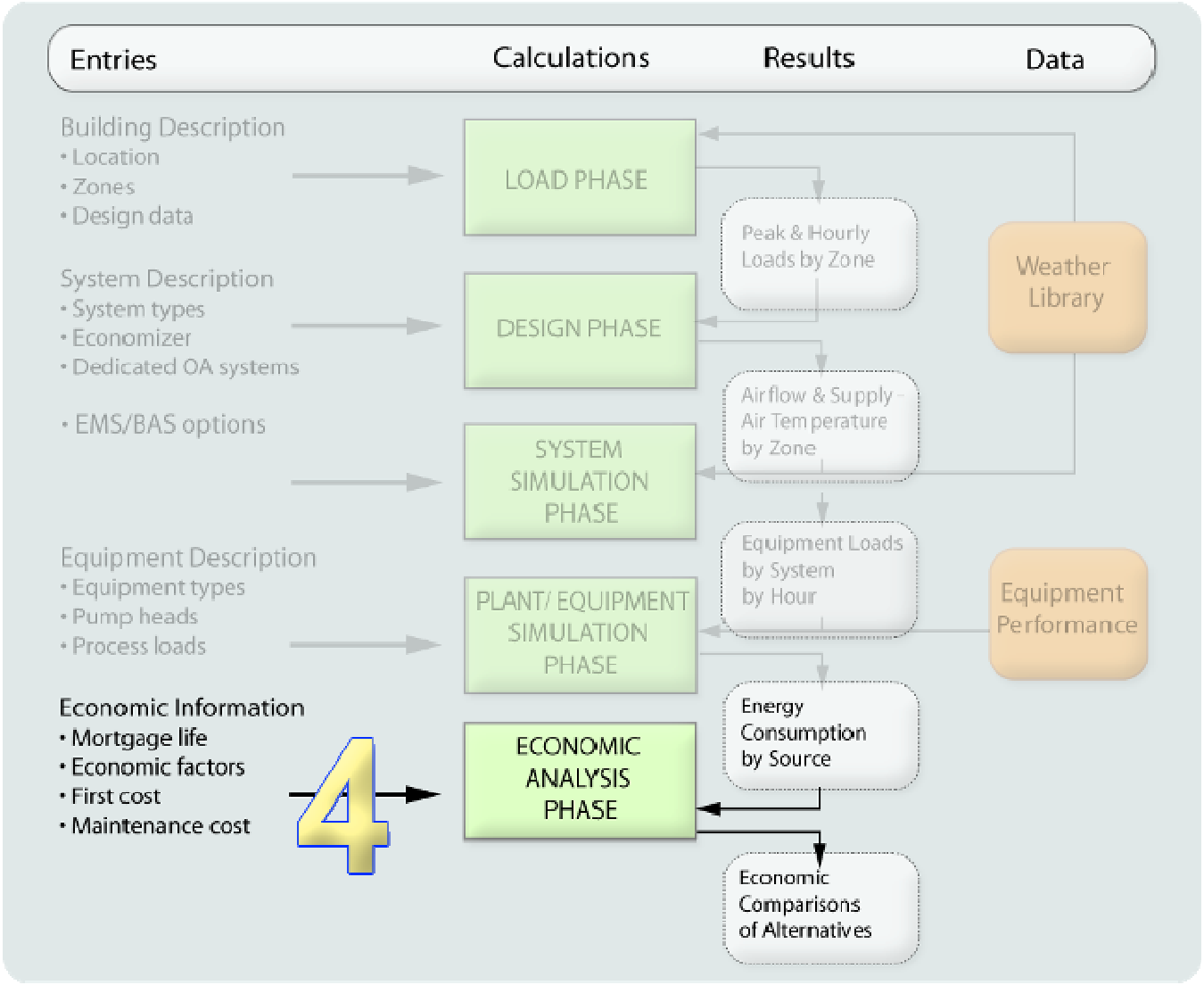
Modeling Functionality *Plant/Equipment Simulation*

Select Features (continued)

- Free cooling
  - Plate & frame
  - Refrigerant migration
  - Strainer cycle
- Double-bundle heat recovery
- Cooling tower with VFD
- Chiller-tower optimization
- Domestic hot water
- Central and distributed geothermal

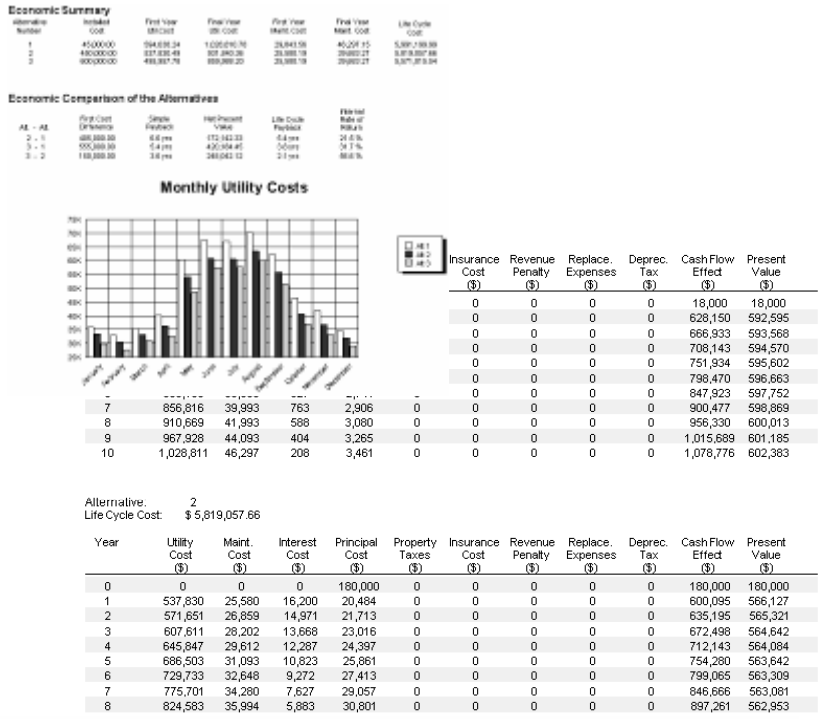


Phase 4: Economic Analysis



Modeling Functionality *Economic Analysis*

- Operation costs
- Custom utility rates
- Multiple alternatives
- Reports show:
  - Cash flow effect
  - Profit and loss effects
  - Payback period
  - Present worth of savings
  - Incremental return on the additional investment
- Not just HVAC



Economic Summary

Economic Comparison of the Alternatives

Monthly Utility Costs

						Insurance Cost ($)	Revenue Penalty ($)	Replace. Expenses ($)	Deprec. Tax ($)	Cash Flow Effect ($)	Present Value ($)
						0	0	0	0	18,000	18,000
						0	0	0	0	628,150	592,595
						0	0	0	0	666,933	593,568
						0	0	0	0	708,143	594,570
						0	0	0	0	751,934	595,602
						0	0	0	0	798,470	596,663
						0	0	0	0	847,923	597,752
7	856,816	39,993	763	2,906	0	0	0	0	0	900,477	598,869
8	910,669	41,993	588	3,080	0	0	0	0	0	956,330	600,013
9	967,928	44,093	404	3,265	0	0	0	0	0	1,015,689	601,185
10	1,028,811	46,297	208	3,461	0	0	0	0	0	1,078,776	602,383

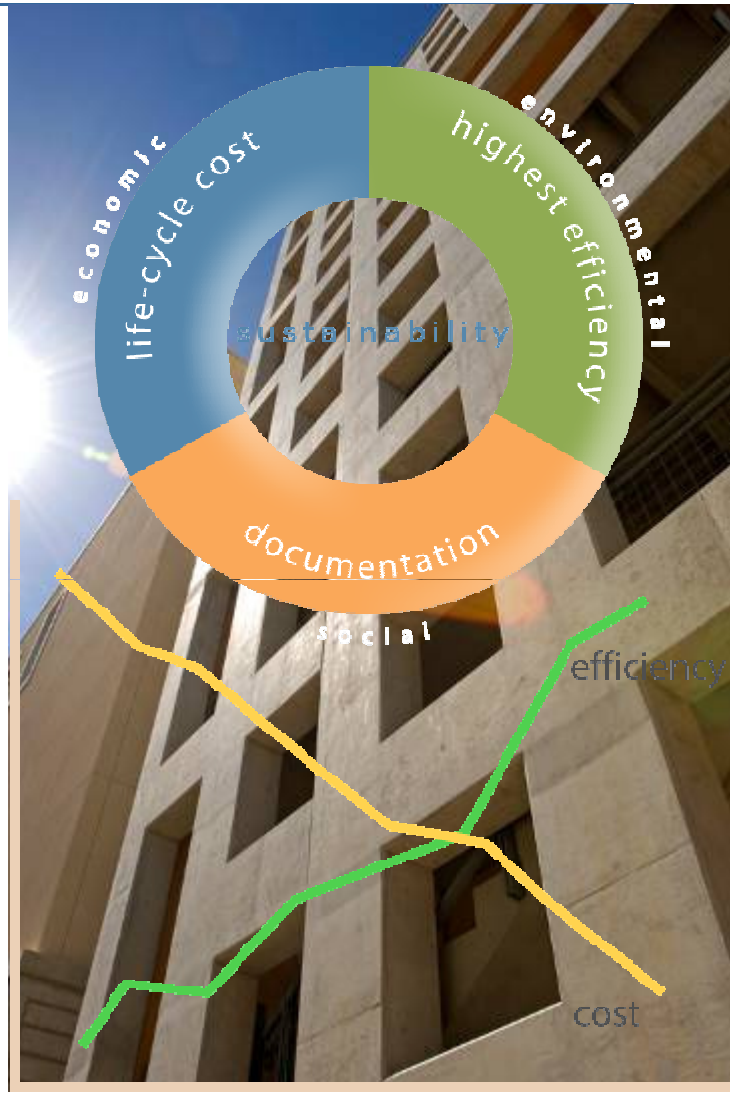
Alternative: 2
Life Cycle Cost: $ 5,819,057.66

Year	Utility Cost ($)	Maint. Cost ($)	Interest Cost ($)	Principal Cost ($)	Property Taxes ($)	Insurance Cost ($)	Revenue Penalty ($)	Replace. Expenses ($)	Deprec. Tax ($)	Cash Flow Effect ($)	Present Value ($)
0	0	0	0	180,000	0	0	0	0	0	180,000	180,000
1	537,830	25,580	16,200	20,484	0	0	0	0	0	600,095	566,127
2	571,651	26,859	14,971	21,713	0	0	0	0	0	635,195	565,321
3	607,611	28,202	13,668	23,016	0	0	0	0	0	672,498	564,642
4	645,847	29,612	12,287	24,397	0	0	0	0	0	712,143	564,084
5	686,503	31,093	10,823	25,861	0	0	0	0	0	754,280	563,642
6	729,733	32,648	9,272	27,413	0	0	0	0	0	799,065	563,309
7	775,701	34,280	7,627	29,057	0	0	0	0	0	846,666	563,081
8	824,583	35,994	5,883	30,801	0	0	0	0	0	897,261	562,953

Alt #	First Cost ($/ton)	First Cost ($/ft²)	Additional First Cost	Total First Cost	Maintenan Cost ($/ton)
1	105.55	0.37	0.00	45,000.00	70.00
2	1,055.50	3.70	0.00	450,000.00	60.00
3	1,407.34	4.93	0.00	600,000.00	60.00

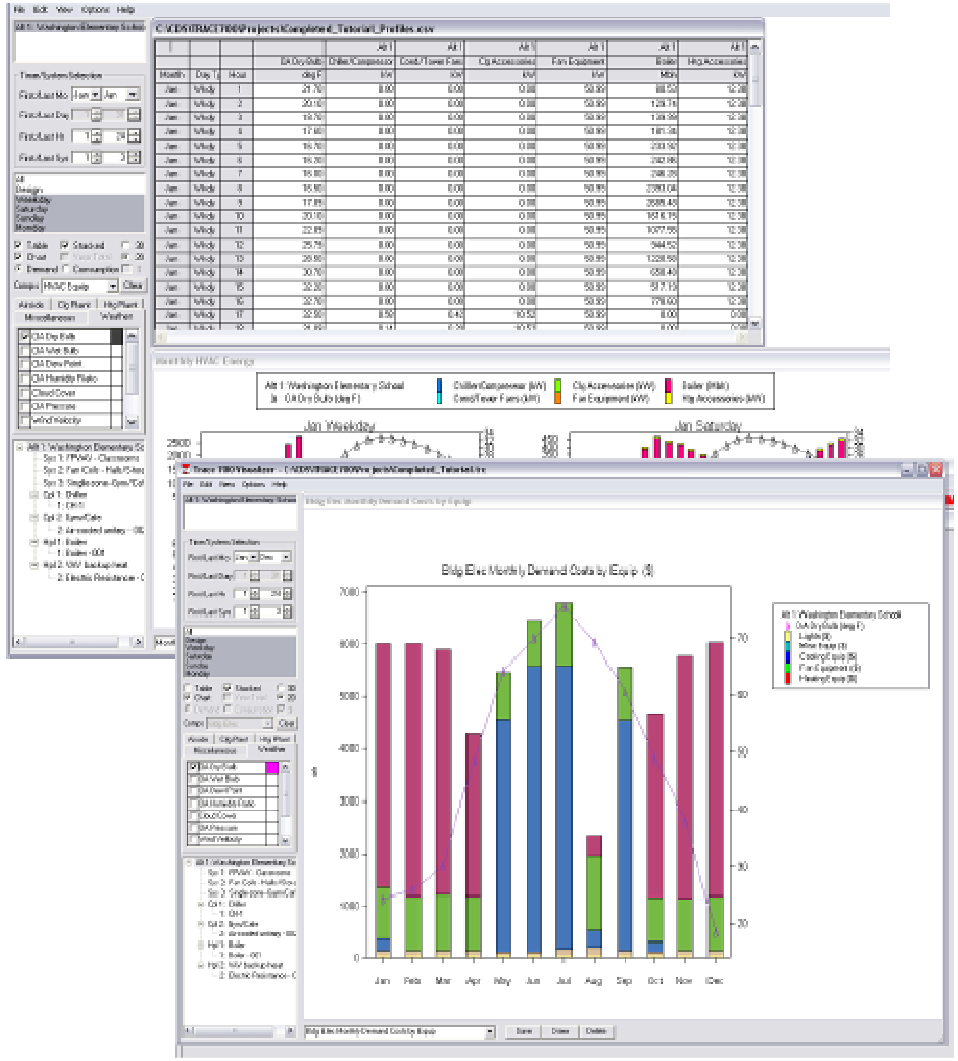
Economic Benefit

- Energy efficiency
- Proven software
  - ASHRAE 140 Compliant
  - ASHRAE 90.1-2004
    - Section 11.2
    - Section G2.2 (LEED Analysis)
- Tax advantage
  (Energy Policy Act of 2005)
- CEC – Title 24



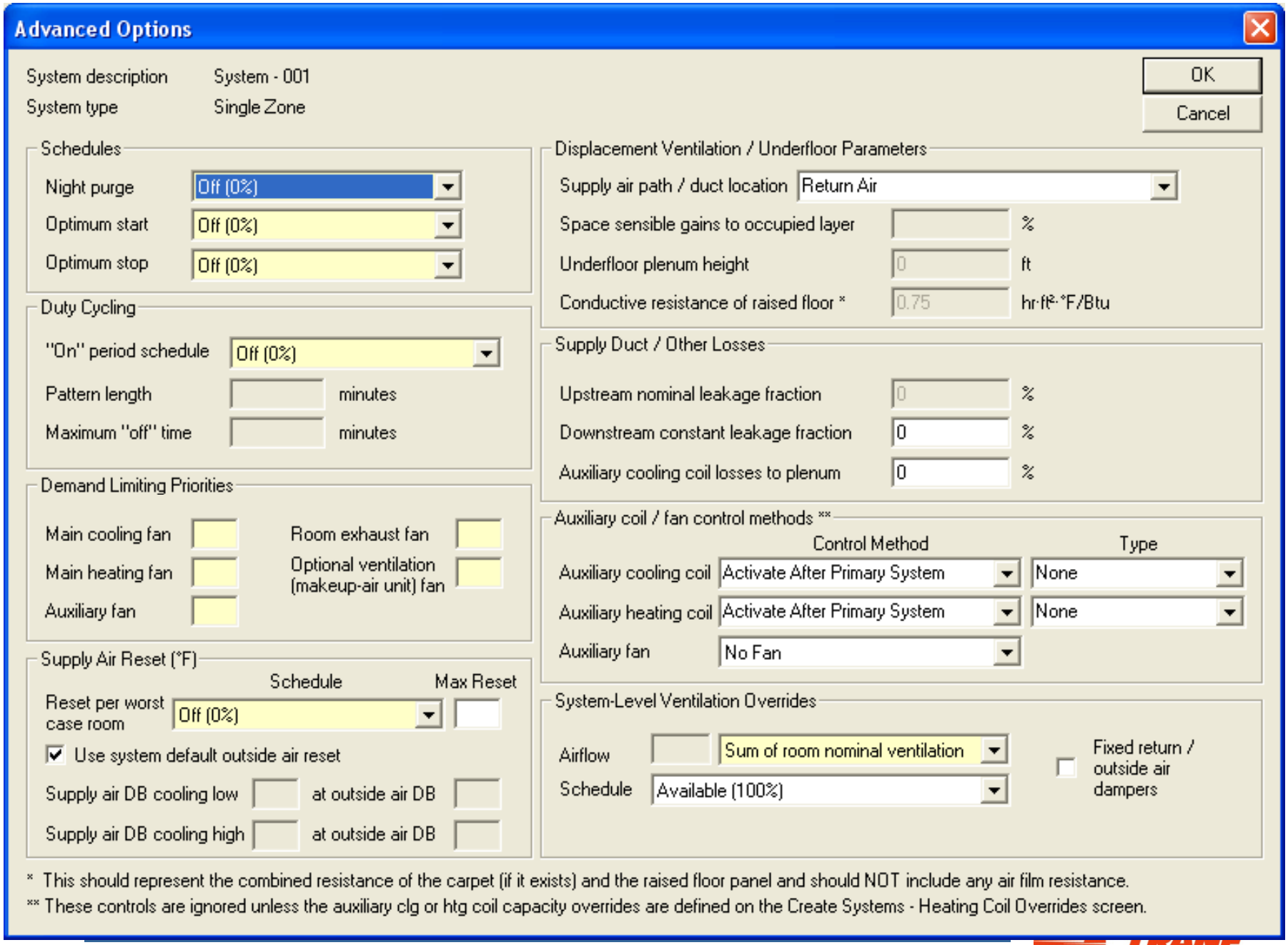
Reports

- Design reports
- Analysis reports
- Detailed reports



10 Simple Rules for Modeling

1. Garbage in Garbage Out
2. Garbage in Garbage Out
3. Garbage in Garbage Out
4. Understand your inputs
5. If it's to good to be true; it's probably not true
    1. Rules of thumb
6. Demystify the black box – understand the output
7. Not every field needs to be filled in


Advanced Options
System description
System - 001
System type
Single Zone
OK
Cancel
Schedules
Night purge
Off (0%)
Optimum start
Off (0%)
Optimum stop
Off (0%)
Duty Cycling
"On" period schedule
Off (0%)
Pattern length
minutes
Maximum "off" time
minutes
Demand Limiting Priorities
Main cooling fan
Main heating fan
Auxiliary fan
Room exhaust fan
Optional ventilation (makeup-air unit) fan
Supply Air Reset (°F)
Schedule
Max Reset
Reset per worst case room
Off (0%)
Use system default outside air reset
Supply air DB cooling low
at outside air DB
Supply air DB cooling high
at outside air DB
Displacement Ventilation / Underfloor Parameters
Supply air path / duct location
Return Air
Space sensible gains to occupied layer
%
Underfloor plenum height
0
ft
Conductive resistance of raised floor *
0.75
hr·ft²·°F/Btu
Supply Duct / Other Losses
Upstream nominal leakage fraction
0
%
Downstream constant leakage fraction
0
%
Auxiliary cooling coil losses to plenum
0
%
Auxiliary coil / fan control methods **
Control Method
Type
Auxiliary cooling coil
Activate After Primary System
None
Auxiliary heating coil
Activate After Primary System
None
Auxiliary fan
No Fan
System-Level Ventilation Overrides
Airflow
Sum of room nominal ventilation
Schedule
Available (100%)
Fixed return / outside air dampers
* This should represent the combined resistance of the carpet (if it exists) and the raised floor panel and should NOT include any air film resistance.
** These controls are ignored unless the auxiliary clg or htg coil capacity overrides are defined on the Create Systems - Heating Coil Overrides screen.

10 Simple Rules for Modeling

1. Garbage in Garbage Out
2. Garbage in Garbage Out
3. Garbage in Garbage Out
4. Understand your inputs
5. If it's to good to be true; it's probably not true
    1. Rules of thumb
6. Demystify the black box – understand the output
7. Not every field needs to be filled in
8. Don't be afraid to try something new
9. Call for help
10. KISS – Keep it super simple

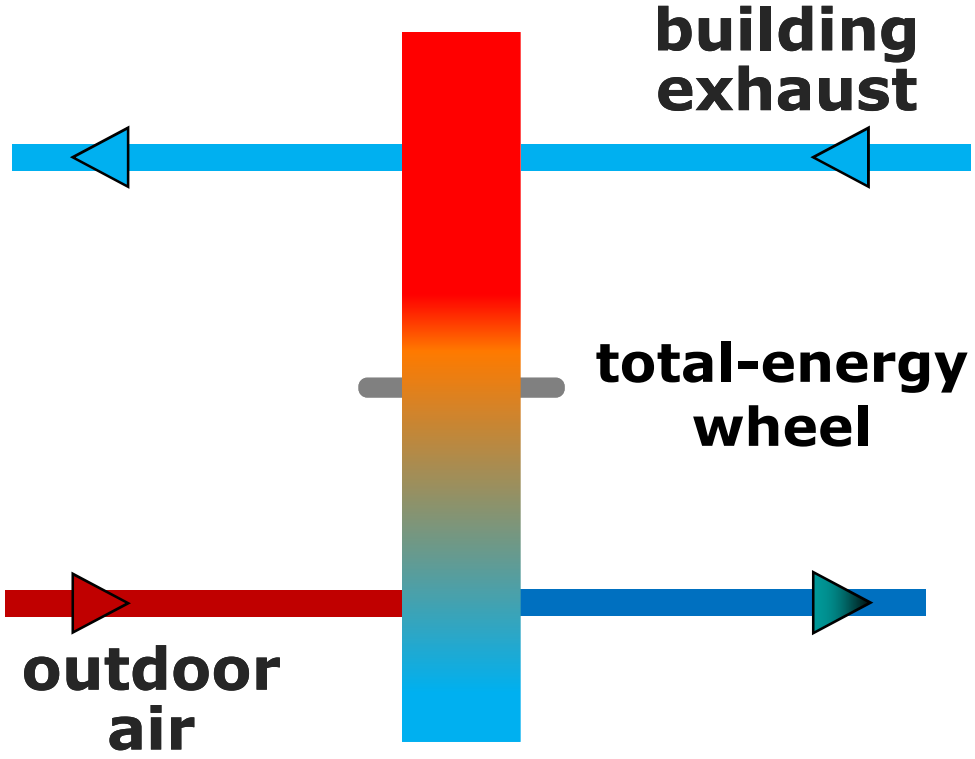
What can energy analysis be used for

- Comparisons between different airside system types
- Comparisons between different waterside system types
- Retrofit Project Qualification – which is the best way to go?
- Fast way to justify potential savings
- ASHRAE 90.1 – if not using prescriptive path
- LEED Projects
- Utility rebate programs
- Bid Reviews

Code Compliance – ASHRAE, IECC

- **ASHRAE 90.1**
  - Fan Pressure optimization
  - Economizers
  - Various energy recovery modeling capabilities
  - Min. Equipment Efficiency in Libraries
  - Building envelope requirements
- **ASHRAE 62.1**
  - Outdoor Air Calculations
  - CO_2 demand control Ventilation
- **LEED**
  - LEED reports

Exhaust-Air Energy Recovery



Exhaust-Air Energy Recovery

Benefits

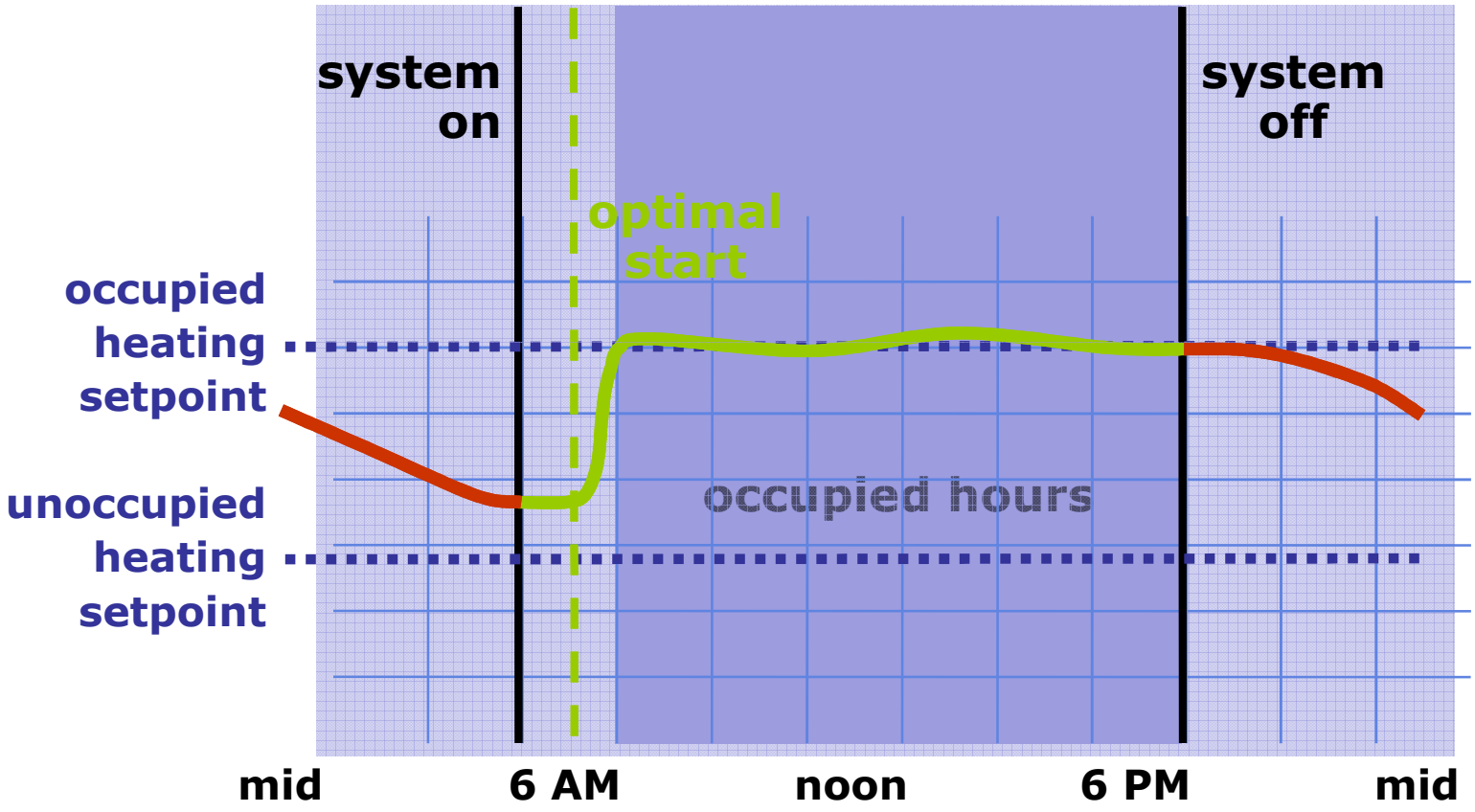
- Reduces cooling, dehumidification, heating, and even humidification energy
- Allows equipment downsizing

Drawbacks

- Increases fan energy
- Requires exhaust air to be routed back to air handling unit

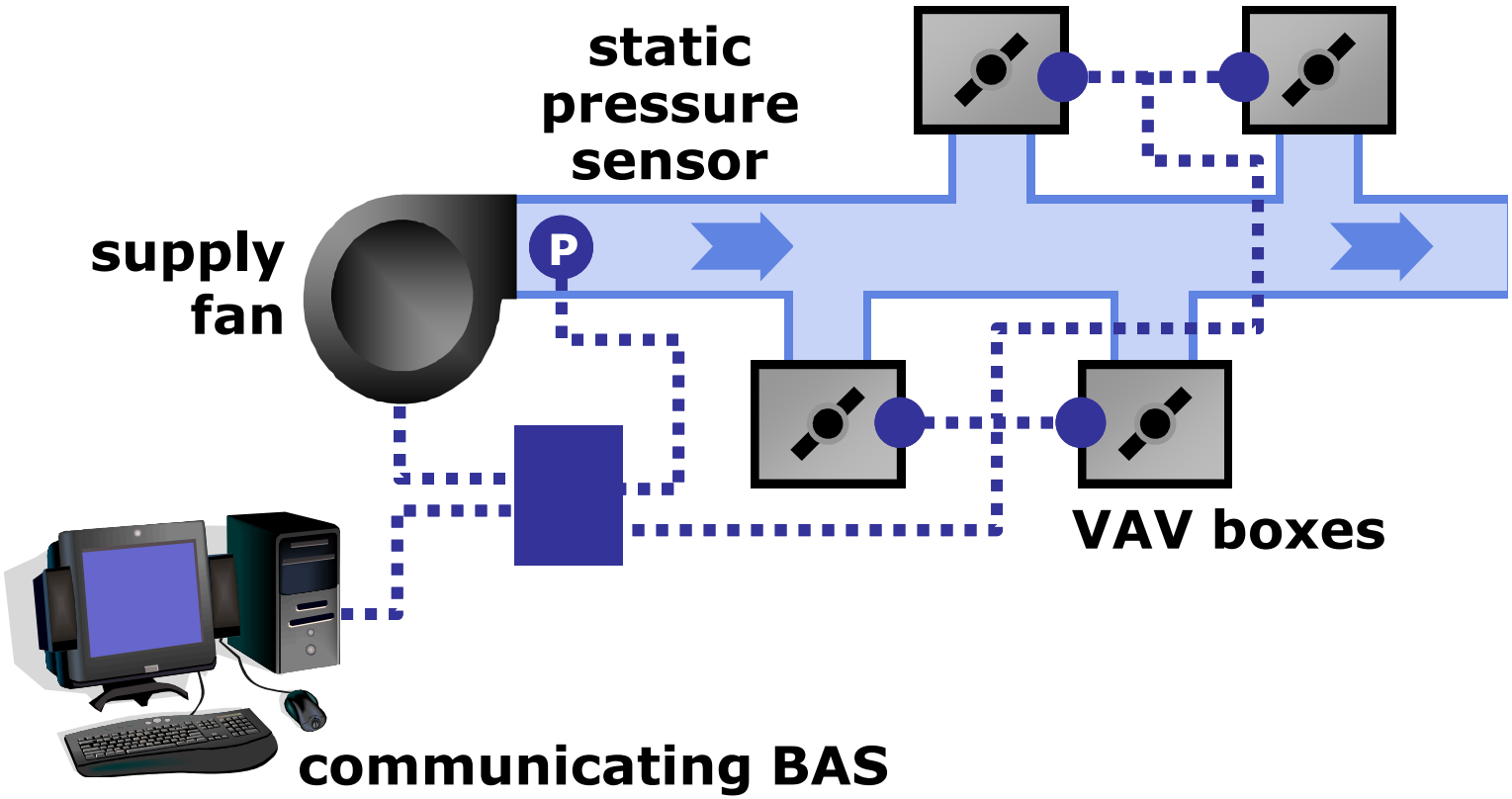
optimized control strategies

Optimal Start



optimized control strategies

Fan-Pressure Optimization



optimized control strategies

Supply-Air-Temperature Reset

Benefits

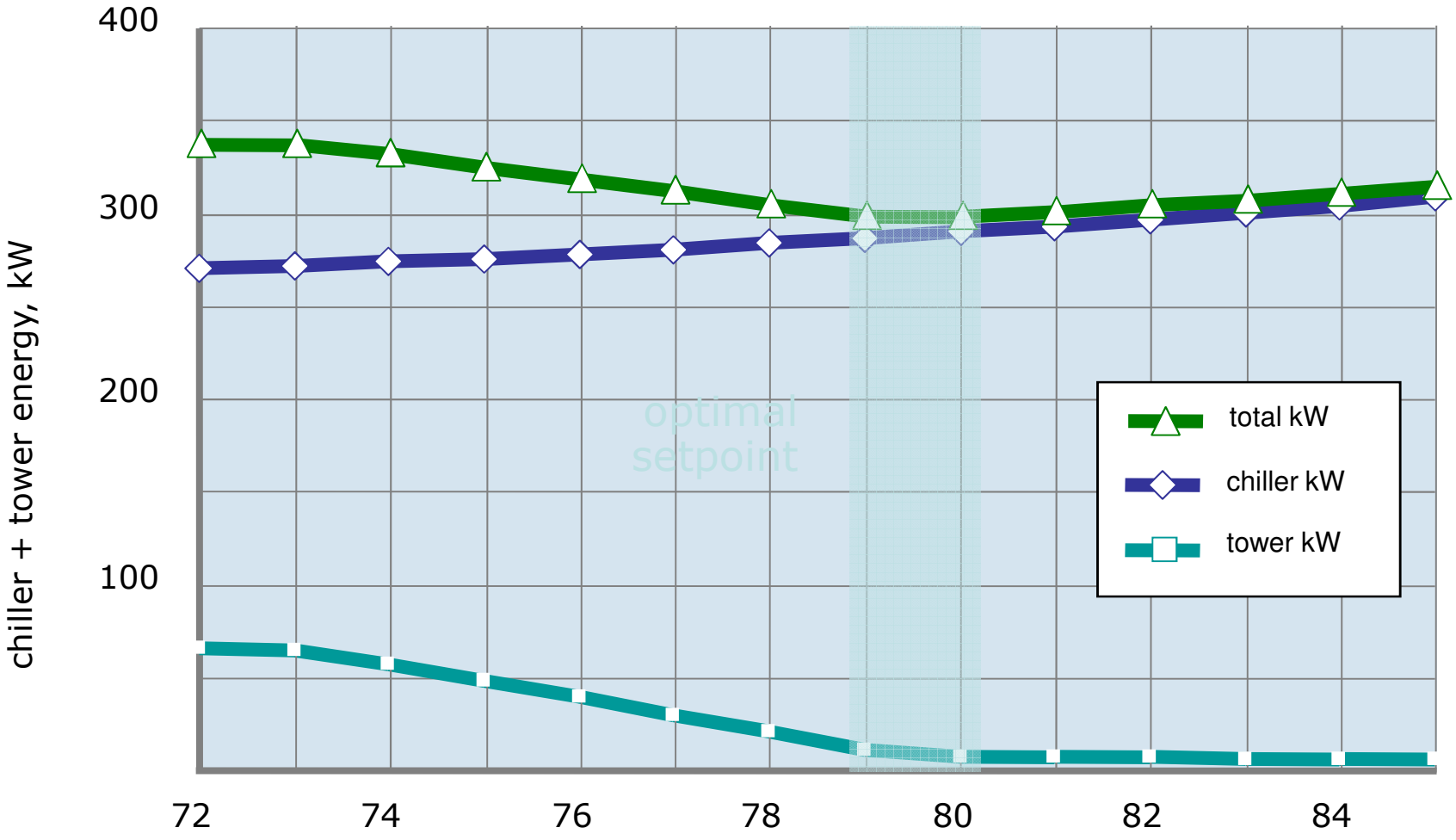
- Decreases compressor energy
- More hours when economizer provides all necessary cooling (compressors shut off)
- Decreases reheat energy

Drawbacks

- Increases fan energy
- Raises humidity levels in zones

Condenser Water Control

Cooling Tower Optimization



Examples of how to use Modleing Software

- Chiller Replacement
  - Different building Types
- Dry Bulb vs. Enthalpy Economizers
  - Energy savings
  - Space conditions
- Live examples…

Example 1: Chiller Replacement

- 650 ton chiller
- High Efficiency vs. ASHRAE 90.1 compliant
- Equivalent Full Load hours 2,500
- Electrical Consumption $0.055/ kW-h
- Electrical Demand $8.00 kW
- 85% Ratchet Rate on demand

Example 1: Chiller Replacement

- 0.576 kW/ton-0.525 kW/ton = **0.051 kW/ton**
- 0.051 kW/ton * 650 tons = **33.15 kW**
- 2,500 EFLH * 33.15kW = **82,875 kW-h**
- **Electrical Consumption Charges**
  - 82,875 kW-h * 0.055 $/kW-h = **$4,558**
- **Electrical Demand Charges**
  - Summer → 33.15 kW * 8 $/kW * 4 months = **$1,061**
  - Winter → 33.15kW * .85 * 8 $/kW * 8 months = **$1,803**

- **Total savings per year = $7,422**

Hospital - Total savings per year = $7,335

Energy Cost Budget / PRM Summary

By TRANE

Project Name:	Date: October 15, 2012
City: North Central	Weather Data: Omaha, Nebraska

Note: The percentage displayed for the "Proposed/Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1			Alt-2		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Space Heating	Electricity	0.0	0	0	0.0	100	0
Space Cooling	Electricity	2,364.2	84	1,187	2,593.4	110	1,302
Heat Rejection	Electricity	449.5	16	162	455.2	101	164
Total Building Consumption		**2,813.7**			**3,048.6**		

		* Alt-1	Alt-2
Total	**Number of hours heating load not met**	0	0
	Number of hours cooling load not met	0	0

	* Alt-1		Alt-2	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	2,813.7	86,201	3,048.6	93,536
Total	**2,814**	**86,201**	**3,049**	**93,536**

K-12 School - Total savings per year = $3,940

Energy Cost Budget / PRM Summary

By TRANE

Project Name:	Date: October 15, 2012
City: North Central	Weather Data: Omaha, Nebraska

Note: The percentage displayed for the "Proposed/Base %" column of the base case is actually the percentage of the total energy consumption.

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		* Alt-1			Alt-2		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Space Heating	Electricity	0.0	0	0	0.0	0	0
Space Cooling	Electricity	563.1	74	1,176	617.4	110	1,291
Heat Rejection	Electricity	200.1	26	166	202.7	101	168
Total Building Consumption		**763.2**			**820.1**		

		* Alt-1	Alt-2
Total	**Number of hours heating load not met**	0	0
	Number of hours cooling load not met	0	0

	* Alt-1		Alt-2	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	763.2	47,720	820.1	51,660
Total	**763**	**47,720**	**820**	**51,660**

University - Total savings per year = $4,844

Energy Cost Budget / PRM Summary

By TRANE

Project Name:	Date: October 15, 2012
City: North Central	Weather Data: Omaha, Nebraska

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		* Alt-1			Alt-2		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Space Heating	Electricity	0.0	0	0	0.0	100	0
Space Cooling	Electricity	1,042.2	74	1,158	1,142.0	110	1,271
Heat Rejection	Electricity	371.4	26	163	376.2	101	165
Total Building Consumption		**1,413.6**			**1,518.2**		

		* Alt-1	Alt-2
Total	**Number of hours heating load not met**	0	0
	Number of hours cooling load not met	0	0

	* Alt-1		Alt-2	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	1,413.6	60,008	1,518.2	64,852
Total	**1,414**	**60,008**	**1,518**	**64,852**

Example 2: Free Cooling & Economizers

- Base Air-cooled chiller with AHU's
- Dry Cooler – Glycol solution
- Dry Bulb Economizer on point 55F
- Enthalpy Economizer comparative on point

Example 2: Free Cooling & Economizers

All hours - Alternative 1

	--- Maximum---				---------- Number of Hours at each Percentage Range ----------											
System/Room Description	%Rh	Mo	Hr	Day	>70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30%
System - 001																
W1-R1 N	78	7	13	Mon	464	298	437	437	503	653	545	1,634	439	109	631	2,610
W1-R2 E	71	7	9	Dsgn	15	569	256	1,001	434	627	328	1,054	494	237	279	3,466
W1-R3 S	71	7	9	Dsgn	15	569	256	1,001	434	627	328	1,054	494	237	279	3,466
W1-R4 W	61	7	23	Mon	0	0	0	633	796	744	538	782	702	542	430	3,593
W1-R5 Int	61	7	23	Mon	0	0	0	425	927	756	530	837	649	584	391	3,661

All hours - Alternative 3

	--- Maximum---				---------- Number of Hours at each Percentage Range ----------											
System/Room Description	%Rh	Mo	Hr	Day	>70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30%
System - 001																
W1-R1 N	100	12	13	Mon	584	1,176	370	25	606	1,347	666	1,283	590	730	700	683
W1-R2 E	100	12	15	Mon	372	933	443	280	1,095	791	576	1,135	450	572	461	1,652
W1-R3 S	100	12	15	Mon	372	933	443	280	1,095	791	576	1,135	450	572	461	1,652
W1-R4 W	61	7	17	Dsgn	0	0	0	355	1,154	1,001	734	1,013	863	602	363	2,675
W1-R5 Int	60	7	17	Dsgn	0	0	0	184	1,085	939	667	974	821	581	532	2,977

All hours - Alternative 4

	--- Maximum---				---------- Number of Hours at each Percentage Range ----------											
System/Room Description	%Rh	Mo	Hr	Day	>70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30%
System - 001																
W1-R1 N	100	12	13	Mon	536	697	490	165	539	1,109	742	1,082	616	401	1,071	1,312
W1-R2 E	100	12	15	Mon	296	554	429	462	992	817	482	1,011	571	332	422	2,392
W1-R3 S	100	12	15	Mon	296	554	429	462	992	817	482	1,011	571	332	422	2,392
W1-R4 W	61	7	17	Dsgn	0	0	0	355	1,098	933	661	951	757	529	364	3,112
W1-R5 Int	60	7	17	Dsgn	0	0	0	184	1,046	880	575	942	708	487	533	3,405

Example 2: Free Cooling & Economizers

Energy Cost Budget / PRM Summary

By TRANE

Project Name:	Date: October 15, 2012
City:	Weather Data: Lincoln, Nebraska

Note: The percentage displayed for the "Proposed/Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 Base no free cooling			Alt-2 Dry cooler			Alt-3 Dry Buld 55F on point			Alt-4 Enthalpy Comparative		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting- Conditioned	Electricity	754.9	52	86	754.9	100	86	754.9	100	86	754.9	100	86
Space Heating	Electricity	11.0	1	5	11.0	100	5	1.8	16	2	1.8	16	2
	Gas	351.9	24	983	351.9	100	983	16.8	5	164	16.8	5	164
Space Cooling	Electricity	238.6	16	350	227.5	95	348	219.3	92	216	190.9	80	216
Pumps	Electricity	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0
Heat Rejection	Electricity	26.5	2	33	26.2	99	35	23.3	88	19	20.1	76	19
Fans - Conditioned	Electricity	27.1	2	4	27.1	100	4	26.1	96	4	26.1	96	4
Receptacles- Conditioned	Electricity	37.6	3	11	37.6	100	11	37.6	100	11	37.6	100	11
Total Building Consumption		**1,447.6**			**1,436.3**			**1,079.7**			**1,048.1**		

		* Alt-1 Base no free cooling	Alt-2 Dry cooler	Alt-3 Dry Buld 55F on point	Alt-4 Enthalpy Comparative
Total	**Number of hours heating load not met**	1,296	1,296	140	140
	Number of hours cooling load not met	354	354	75	28

	* Alt-1 Base no free cooling		Alt-2 Dry cooler		Alt-3 Dry Buld 55F on point		Alt-4 Enthalpy Comparative	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	1,095.6	31,386	1,084.3	31,071	1,062.9	27,010	1,031.3	26,399
Gas	351.9	2,816	351.9	2,816	16.8	134	16.8	134
Total	**1,448**	**34,202**	**1,436**	**33,887**	**1,080**	**27,144**	**1,048**	**26,534**

Example 3: Bid Review Water Pressure Drop

			Base Chiller
	Efficiency	kW/ton	0.565
Evaporator:			
	GPM		4500
	EWT	F	56
	LWT	F	44
	P.D.	Ft./W.G.	24.1
	Tube Thickness		0.028
	Fouling Factor		0.0001
Condenser:			
	GPM		6750
	EWT	F	94.7
	LWT	F	85
	P.D.	Ft./W.G.	33
	Tube Thickness		0.028
	Fouling Factor		0.00025

Example 3: Bid Review Water Pressure Drop

			Base Chiller	Alt: 1	Alt: 2	Alt: 3
	Efficiency	kW/ton	0.565	0.565	0.561	0.557
Evaporator:						
	GPM		4500	4500	4500	4500
	EWT	F	56	56	56	56
	LWT	F	44	44	44	44
	P.D.	Ft./W.G.	24.1	8.16	8.16	8.16
	Tube Thickness		0.028	0.028	0.028	0.028
	Fouling Factor		0.0001	0.0001	0.0001	0.0001
Condenser:						
	GPM		6750	6750	6750	6750
	EWT	F	94.7	94.7	94.7	94.7
	LWT	F	85	85	85	85
	P.D.	Ft./W.G.	33	10.46	10.46	8.91
	Tube Thickness		0.028	0.028	0.028	0.028
	Fouling Factor		0.00025	0.00025	0.00025	0.00025

Example 3: Comparison vs. Base bid

Energy Cost Budget / PRM Summary

By Trane

Project Name:	Date: January 30, 2008
City: North East	Weather Data: Washington, D.C.

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		Base Chiller			Alt: 1			Alt: 2			Alt: 3		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Space Heating	Electricity	2.5	0	2	2.5	100	2	2.5	100	2	2.5	100	2
	Gas	0.0	0	0	0.0	100	0	0.0	100	0	0.0	100	0
Space Cooling	Electricity	22,167.2	74	29,392	22,167.2	100	29,392	21,569.7	97	28,799	21,267.1	96	28,464
Pumps	Electricity	1,871.6	6	1,945	639.2	34	690	425.2	23	540	439.5	23	511
Heat Rejection	Electricity	5,963.4	20	4,095	5,963.4	100	4,095	5,942.9	100	4,084	5,932.5	99	4,078
Total Building Consumption		30,004.7			28,772.3			27,940.4			27,641.6		

Total	Number of hours heating load not met	331	331	331	331
	Number of hours cooling load not met	0	0	0	0

$128,624

$109,548

$67,807

	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	30,004.7	1,857,605		,789,798	27,940.4	1,748,057	27,641.6	1,728,982
Gas	0.0	1	0.0	1	0.0	1	0.0	1
Total	30,005	1,857,606	28,772	1,789,799	27,940	1,748,058	27,642	1,728,982

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